Yulia Frumer, *Making Time: Astronomical Time Measurement in Tokugawa Japan,* Chicago: University of Chicago Press, 2018, 272 pp.

Takehiko Hashimoto

[Takehiko Hashimoto is professor of the history of science and technology at the University of Tokyo. He has written and edited articles and books on clocks, a social history of time, standardization, the history of aerodynamics and aeronautics, and the use of images in the history of science and technology. Contact: takehiko.hashimoto@gmail.com]

Yulia Frumer's *Making Time: Astronomical Time Measurement in Tokugawa Japan* is an excellent scholarly book on the history of clocks and time-counting systems in Edo-period (Tokugawa, 1600-1868) Japan. Like Westerners in pre-modern times, the Japanese in the Edo period counted time differently from the present 24-hour time system. To represent their seasonal time system, they modified clocks originally imported from the West and developed several original designs and mechanisms to indicate time on clock faces. There are several scholarly books, and many popular books, available on the history of clocks and the timekeeping system in pre-modern Japan, both in Japanese and in English, but they tend to be mostly limited to the description of the artifacts, their technical features, and the scientific backgrounds of the time-counting system. Frumer's book goes beyond them by covering many relevant historical documents authored throughout the Edo period, showing how these authors thought about time and designed, developed, and used timekeeping devices for their various purposes.

In the introduction to the book, the author first refers to this fact—the existence of unique clocks and timekeeping system in the Edo period—and then goes on to discuss the inadequacy of the arguments that calendric reform in the early Meiji period, including the introduction of the Western timekeeping system, was a logical step considered necessary for the subsequent introduction of Western modern institutional and technological systems. The author emphasizes in the last chapter the role and significance of the enlightened thinkers of the later Edo period who well understood the superiority of the clock and time systems prevalent in the West. The main focus of the book is on the ideas and uses of timekeeping methods by these learned persons.

The first two chapters provide some basic explanations of the seasonal time-counting system adopted in Edo-period Japan (Chapter 1) and the mechanism, social diffusion, and different designs of Japanese clocks called *wadokei* 和時計 (Chapter 2). Unlike the system in ancient and medieval Europe, the time-counting system in the Edo period designated dawn and dusk as the beginning and end of daytime. The author succinctly explains

this, but refrains from going into technical details such as precise quantitative definitions of dawn and dusk. She also relegates the numerous Japanese terms for time and seasons to the appendices. However, she does explain the key mechanisms of the clocks referring to their components as well as their Japanese names and their English meanings. The verge and foliot mechanism was used in the early type of *wadokei*, and the foliot was translated as *tempu* 天府 (or 天符) whose Chinese characters would mean "the seat of the heaven." These and subsequent chapters are full of such explanatory accounts that should intrigue the readers of this esoteric history of pre-modern Japan.

The next three chapters deal with the use of these clocks for astronomical observation, geodetic survey, and marine navigation. For astronomical observations, the use of a timekeeping device was necessary for making accurate astronomical tables; for geodetic survey and marine navigation, the use of timekeeping device and astronomical tables offers observers precise geographical locations. The author provides accounts of not only such famous figures in Japanese history as Asada Gōryū 麻田剛立, Takahashi Yoshitoki 高橋至時, Hazama Shigetomi 間重富, and Inō Tadataka 伊能忠敬, but also many other lesser-known figures such as Ōno Yasaburō 大野弥三郎 and Tokura Sukeyuki 戸倉祐之. Of them, Ōno was a noted clock maker and worked as the instrument maker in Inō's large geodetic-survey project. The author emphasizes the importance of Ōno's role in the mission, because Inō decided to adopt Ōno's value of the unit of length of *shaku* 尺 (Japanese equivalent unit for a foot) to calibrate all the measuring tools. Though it is just a paragraph-length note, the author does not fail to mention such important historical remarks throughout the book.

Chapter 6 turns our attention to the case of a local clan, Kaga 加賀 domain, where a unique timekeeping system was developed in the early nineteenth century. When the scholarly bureaucrat Endō Takanori 遠藤高璟 studied the timekeeping system in the domain, he found that people followed a peculiar system that differed greatly from the official one. He eventually devised a new system that was close to the system prevalent in Kaga society. His system inserted a half Edo hour at the ends of daytime as well as nighttime. In preparing and executing this system, Endō made accurate astronomical observations, and used an original and precise pendulum clock. Yet the new system was largely not followed by residents. The episode provides an interesting case to consider the theory and practice of the timekeeping system in Edo-period Japan. Chapter 7 discusses several clockmakers and the relationship of their products to the entertainment automata known as *karakuri*. Of them, Tanaka Hisashige 田中久重, also known as "Karakuri Giemon" からくり儀右衛門 among the Japanese today, was the most notable figure. From his late teens, he made his living by making *karakuri* machines and entertaining spectators on

festive occasions. In his forties, he made a rather anachronistic clock-working model of the universe ordered by a monk named Entsū 円通 but soon afterwards he made a large timekeeping machine of his own design, based on his studies of current astronomical and calendric ideas. Chapter 8 discusses the history of antecedents prior to the adoption of the Western calendric and time-counting system in 1873 by the Meiji government. The author mentions the enlightened Japanese thinkers of the eighteenth and nineteenth centuries and shows that it was their ideas that prepared the background for the adoption of Western calendric system in Japan.

Finally, the conclusion of the book succinctly summarizes the entire story of clocks and their uses in the Edo period and, based on this historical analysis, the author proposes three historiographical and methodological implications. Of them, the second one concerns the conditions surrounding the technological transfer. If we see the introduction of Western clocks into Japan at the turn of the seventeenth century, we could see how Japanese understood and used these clocks differently from their original users in the West. As the author discusses in the main part of the book, those who studied astronomy came to recognize the importance of the Western timekeeping system, used pendulum clocks and relevant mathematical tools, and came to understand time in a way similar to that of European astronomers. And yet, the author points out, their understanding was only similar, and not quite identical. As for ordinary citizens living in late-Edo and early-Meiji Japan, they "had to first experience Western time" so as to be prepared to understand the Western timekeeping system.

Frumer's *Making Time* thus focuses attention mainly on those who received an astronomical education, and on the processes through which Western clocks and the Western timekeeping system came to take root in Japanese society through their activities. This focus is reflected in its subtitle: "Astronomical Time Measurement in Tokugawa Japan." The historical question of how ordinary Japanese citizens used clocks and conceived time is not the author's main focus of analysis. The reviewer would like to make a few comments on this question in relation to the book's contents. The history of *wadokei* in the Edo period has severe limitation, in the level of possible analysis, due to the unavailability of relevant historical documents. There are numerous clocks extant in collections of old clocks nationwide. However, almost all the clocks in these collections lack information regarding their places of origin, makers, and users. Sources by and about clockmakers are also very few. It is, however, theoretically possible to examine and analyze, probably using scientific methods, existing clocks and their parts to explore their origins. If such studies were indeed carried out, historians would be able to do a more fine-grained analysis about the historical evolution of Japanese clocks as well as their relationship to local societies.

As the author explains in Chapter 1, the system of time bells was well developed and prevailed widely over Japan. Just one passing note: though the author suggests the possible popularity of clocks from the early eighteenth century, it seems to the reviewer that the source the author cites on that point (p. 46) is, in fact, inconclusive. It is more likely that ordinary people depended on time bells to know the time. In the capital city, the system of time bells was well established to inform their residents about time. But how accurate their timing was—accurately corresponding to the time designated by the official timekeeping system—is another matter. Urai Sachiko 浦井祥子, a historian of time bells of the Edo period, shows a document preserved in the Kan'eiji 寛永寺 Temple—a prominent place to ring the time bell—which indicates a peculiar way of ringing the bell slightly different from the official time system that uniformly divided the daytime and the nighttime.[1] We know the seasonally variable time-counting system in Edo-period Japan and its theoretical and official quantitative values for each day of the calendar. Yet, we do not know exactly at what time the time bells were really rung throughout Japan and what ordinary people actually knew about their current time.

The historical data on these two points - the origins of extant clocks and the working of the time information system in reality - are too difficult to obtain at the moment. In default of this historical information, Frumer's *Making Time* provides readers accurate and sufficiently detailed descriptions about clocks and timekeeping system in pre-modern Japanese society. Though its scope focuses on specific problems in the history of Japanese clocks and timekeeping system, the author's arguments and historiographical implications developed based on her historical investigations are well articulated and insightful. The book is an accomplished product of the author's laborious scholarly research, covering existing primary and secondary sources quite exhaustively. It is also a vividly narrated monograph full of intriguing historical episodes and background stories interspersed throughout the book. I would like to recommend it to everyone interested in Japanese history, the history of technology, and the history of time-related science and technology.

Reference

Urai, Sachiko 浦井祥子 (2002), *Edo jidai no jikoku to toki no kane* 江戸の時刻と時の鐘, Tokyo: Iwata shoin.

[1] Urai (2002), pp. 183-192.